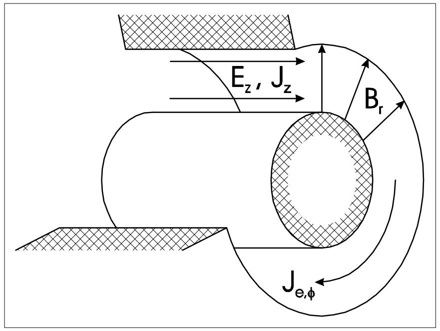
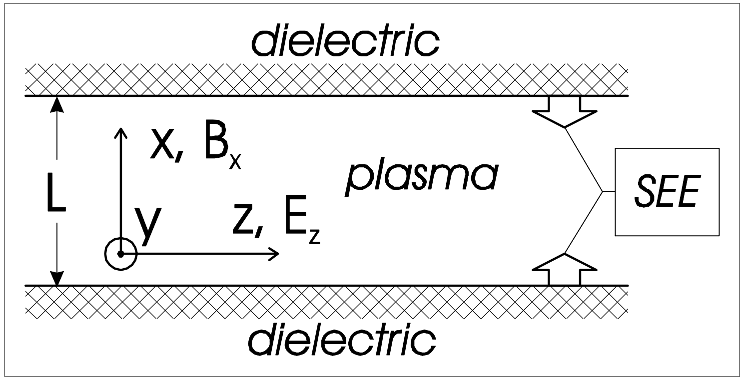
Simulations of secondary electron emission (SEE) effects in a plasma slab in crossed electric and magnetic fields

[Sydorenko, Smolyakov, in 46th APS DPP, (Savannah, GA, 2004), NM2B.008.]

Hall thruster, cylindrical geometry:



1D3V PIC simulations, plain geometry, approximation of accelerating region of a Hall thruster:



Motivation:

Electron temperature in the accelerating region of a Hall thruster (40 eV) is higher than the temperature of charge saturation of SEE in Maxwellian plasma (17 eV). [Staack, Raitses, Fisch, Appl. Phys. Lett. 84, 3028 (2004).]

Objective:

The investigation of modification of electron velocity distribution function by SEE effects.

Simulation requirements:

Both the sheath and the bulk plasma must be resolved.

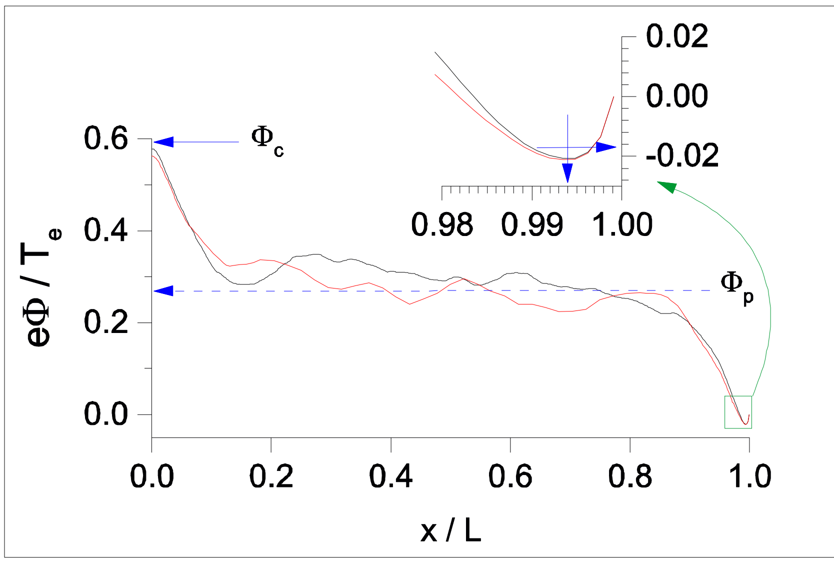
PIC code:

Electrostatic implicit multi-scale with non-uniform grid constant in time. [Friedman, Parker, Ray, Birdsall, J. Comput. Phys. 96, 54 (1991).] The external fields B_x and E_z are assumed constant.

Simulations of SEE effects in a plasma slab…
Benchmarking of the multi-scale code.

The code was applied for simulations of the region between the Maxwellian plasma source (x=0) and the wall with SEE (x=L). No collisions, zero external fields.

Previously such problem was considered by Schwager. [Phys. Fluids B 5, 631 (1993).]



Snapshots of the profile of potential.

The insertion zooms into the potential dip near the emitting wall.

- Blue arrows – Schwager's data.
- Black curves – uniform grid.

$$\Delta x = l_{De}/32, \Delta t = 1/(4w_{pe})$$

- Red curves – nonuniform grid.

$$\Delta x_{\min} = l_{De}/32, \Delta x_{\max}/\Delta x_{\min} = 16;$$

$$\Delta t_{\min} = 1/(128 w_{pe}), t_{\max}/\Delta t_{\min} = 64$$

- The results of the single-scale and multi-scale simulations are close to each other and reproduce the results of Schwager.
- The multi-scale simulation is 8 times faster than the single scale simulation.